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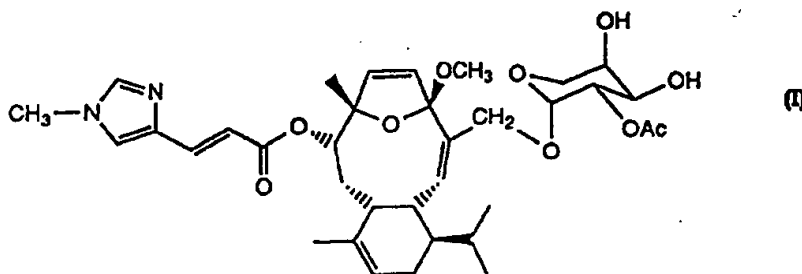


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<b>(21) International Application Number:</b> PCT/US95/14155 <b>(22) International Filing Date:</b> 1 November 1995 (01.11.95) <b>(30) Priority Data:</b> 08/336,518 9 November 1994 (09.11.94) US <b>(71) Applicant:</b> THE REGENTS OF THE UNIVERSITY OF CALIFORNIA [US/US]; 22nd floor, 300 Lakeside Drive, Oakland, CA 94612-3550 (US). <b>(72) Inventors:</b> FENICAL, William, H.; 1128 Highland Drive, Del Mar, CA 92014 (US). JENSEN, Paul, R.; 4340 1/2 Louisiana Street, San Diego, CA 92104 (US). LINDEL, Thomas; Nottulmer Landweg 44B, D-48161 Muenster (DE). <b>(74) Agent:</b> BERLINER, Robert; Robbins, Berliner & Carson, 5th floor, 201 N. Figueroa Street, Los Angeles, CA 90012-2628 (US).	<b>(81) Designated States:</b> AL, AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, LS, MW, SD, SZ, UG). <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>	

**(54) Title:** ELEUTHEROBIN AND ANALOGS THEREOF



**(57) Abstract**

Eleutherobin is a glycosylated diterpene which has structural formula (I). Eleutherobin is a cytotoxic agent which is toxic to carcinoma cancer cells. Analogs of eleutherobin are also disclosed.

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## ELEUTHEROBIN AND ANALOGS THEREOF

## BACKGROUND OF THE INVENTION

**5            This invention was made with Government support under Grant No. CA50750, awarded by the National Cancer Institute. The Government has certain rights in this invention.**

## **1. Field of the Invention**

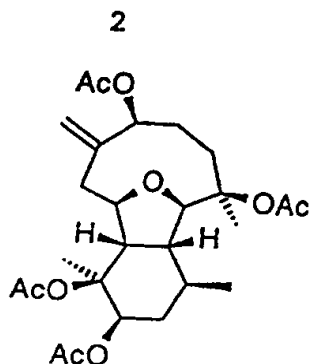
10           The present invention relates generally to pharmacologically active compounds which are isolated from marine life, such as sea whips, sea fans and soft corals. More particularly, the present invention relates to such naturally occurring marine products and analogs thereof which include a diterpene core of the eunicellian class.

## 2. Description of Related Art

There has been and continues to be a great deal of interest in isolating pharmacologically active compounds from marine sources. Numerous useful compounds have been isolated from marine organisms ranging from simple bacteria to complex plants and animals. The compounds themselves also range from relatively simple compounds to extremely complex compounds with the range of pharmacological utility also being quite large and varied. Sea fans, sea whips and soft corals have been an especially fertile source of compounds which are pharmacologically active.

Eunicellin is a naturally occurring marine compound which was first isolated from the gorgonian *Eunicella stricta* in 1968 (O. Kennard, D.G. Watson, L. Riva de Sanservierine, B. Tursch, R. Bosmans, C. Djerassi, *Tetrahedron Lett.* **1968**, 2879-2883). Eunicellin is a diterpene compound which has the following chemical structure

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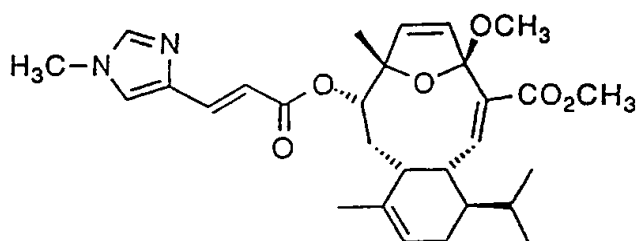


No bioactivity for eunicellin has been reported.

Another naturally occurring marine compound is *Sarcodictyin A*.

10 *Sarcodictyin A* was first isolated in the late 1980's from the mediterranean stolonifer *Sarcodictyon roseum* (M. D'Ambrosio, A. Guerriero, F. Pietra, *Helv. Chim. Acta* **1987**, 70,2019-20257; and M. D'Ambrosio, A. Guerriero, F. Pietra, *ibid.* **1988**,71, 964-976). The chemical structure of Sarcodictyin A is

15



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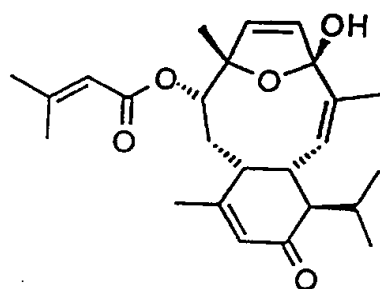
No bioactivity for Sarcodictyin A has been reported.

25 The valdivones are a group of marine compounds which were initially isolated from the South African soft coral *Alcyonium valdivae* in 1993 (Y. Lin, C.A. Bewley, D.J. Faulkner, *Tetrahedron* **1993**, 49, 7977-7984). Valdivone A and Valdivone B are two examples of this type of compound. The chemical formulas for these two compounds are

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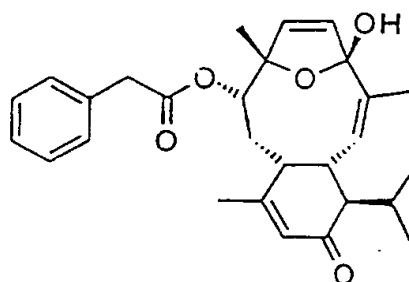
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Valdivone A

10



15

Valdivone B

20 Both Valdivone A and Valdivone B have been shown to possess anti-inflammatory activity.

The above mentioned compounds are a few examples of the many different types of materials which have been isolated as a result of the many scientific efforts to recover useful chemicals from marine life.

25 These efforts continue today and will continue into the future as new chemical compounds are isolated, identified and found to be pharmacologically useful.

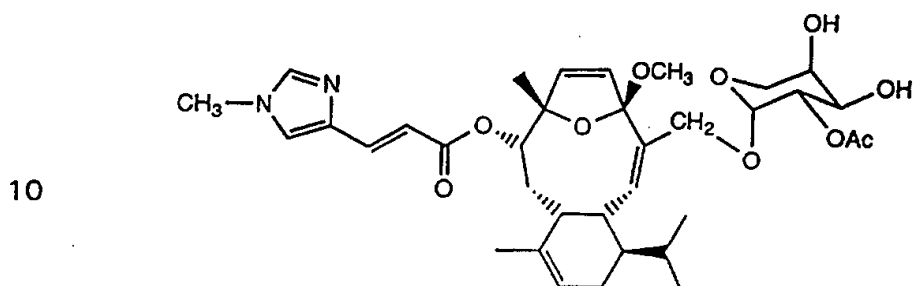
#### SUMMARY OF THE INVENTION

30 In accordance with the present invention a new compound has been isolated from the Indian Ocean soft coral *Eleutherobia cf. albiflora*.

*E. albiflora* is a red-colored cnidarian relatives of which are located throughout the world in locations such as Western Australia, the Pacific and Indian Oceans.

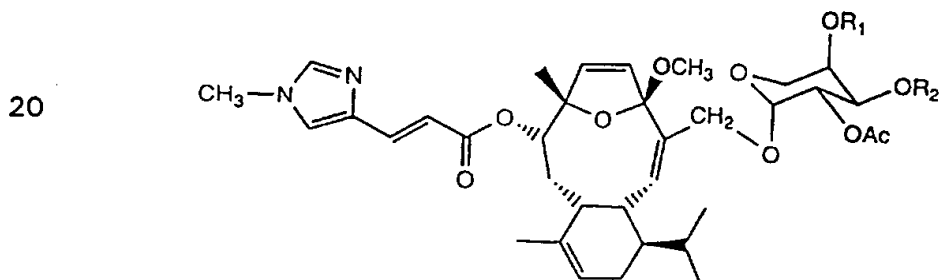
The isolated compound has been given the name "Eleutherobin"

and has been found to have the following chemical formula:



Eleutherobin has been tested for pharmacological activity and found to be an effective cytotoxin.

As a feature of the present invention, analogs of eleutherobin are disclosed which have the general formula:



where R<sub>1</sub> and R<sub>2</sub> are hydrogen or acyl residues having from 1 to 6 carbon atoms. These closely related analogs are also expected to exhibit cytotoxic activity.

The above described and many other features and attendant advantages of the present invention will become better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is the formula for eleutherobin showing the atom labels.

FIG. 2 is the formula for eleutherobin showing the  $^1\text{H}$  NMR  
5 chemical shifts at 500 MHz in chloroform- $d_1$ .

FIG. 3 is the formula for eleutherobin showing the  $^{13}\text{C}$  NMR  
chemical shifts at 50 MHz in chloroform- $d_1$ .

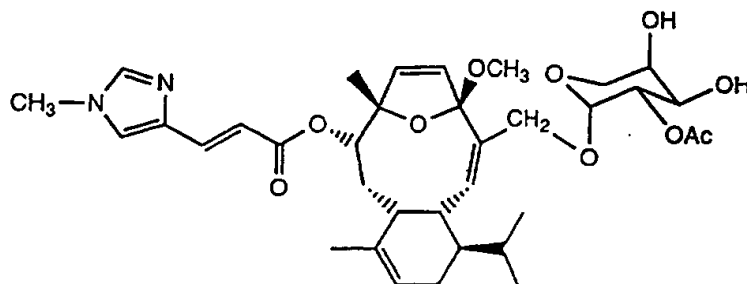
10 FIG. 4 is a structural diagram showing the nuclear Overhauser  
enhancement (NOE) correlations of the terpene core of eleutherobin at  
500 MHz in chloroform- $d_1$ .

FIG. 5 is a schematic diagram of an exemplary separation scheme  
15 for isolating eleutherobin from *Eleutherobia* spp.

### DETAILED DESCRIPTION OF THE INVENTION

The present invention is based on the discovery of a specific  
glycosylated diterpene which was initially isolated from *Eleutherobia* cf.  
20 *albiflora*. *E. albiflora* is a red-colored cnidarian which is located in  
Western Australia off the North West Cape near Exmouth. The  
glycosylated diterpene has been given the name "Eleutherobin" and has  
been identified as having the following formula:

25



30

The molecular formula of eleutherobin as determined by high resolution FAB mass spectrometry (HRFABMS) is  $C_{35}H_{48}N_2O_{10}$ , indicating 13 degrees of unsaturation. As in the case of other natural products, the intensity of the molecular ion peak was small, while on adding sodium, a strong signal corresponding to the  $[M+Na]^+$  ion was detected.

The physical and spectroscopic data for eleutherobin are set forth in TABLES 1-4.

10

TABLE 1

15

20

Eleutherobin	
yield:	15 mg from 150 g freeze dried soft coral (0.01%)
TLC:	$R_f$ + 0.33 (chloroform/methanol (9:1))
$[\alpha]D^{25}$	= -49.3° (c = 3.0, methanol)
HRFABMS:	$[C_{35}H_{48}N_2O_{10}Na]^+$ calc. 679.3207      obs. 679.3174 (-4.8ppm)
IR (NaCl, neat):	$\nu$ = 3360 $cm^{-1}$ , 2960, 2922, 2856, 1722, 1657, 1450, 1372, 1243, 1152, 1055.
UV (methanol):	$\lambda_{max}$ (log $\epsilon$ ) = 290 nm (3.824).



TABLE 2

NMR spectral data for eleutherobin				
	label	<sup>13</sup> C NMR <sup>a</sup>	<sup>1</sup> H NMR <sup>b</sup>	HMBC correlations <sup>c</sup>
5	1	34.3(d)	3.96(m)	none
	2	137.4(d)	5.56(d, 9.2 Hz)	C-4, C-14, C-15
	3	132.8(s)		
	4	115.9(s)		
10	5	131.0(d)	6.12(d, 5.9 Hz)	C-4, C-6, C-7
	6	133.7(d)	6.09(d, 5.9 Hz)	C-4, C-5, C-7
	7	89.9(s)		
	8	81.5(d)	4.82(d, 7.7 Hz)	C-6, C-7, C-16, C-29, C-1'
	9	31.5(t)	1.39(m)	C-1, C-7
15			1.81(m)	C-1, C-8, C-10
	10	38.7(d)	2.61(m)	none
	11	134.2(s)		
	12	121.3(d)	5.28(m)	C-17
20	13	24.5(t)	1.98(m)	none
			2.32(m)	none
	14	42.4(d)	1.23(m)	none
	15	69.1(t)	3.88(d, 12.4 Hz)	C-2, C-3, C-4, C-1"
			4.31(d, 12.4 Hz)	C-2, C-3, C-1"
25	16	24.3(q)	1.45(s)	C-7, C-8
	17	21.9(q)	1.52(s)	C-11, C-12
	18	29.1(d)	1.57(m)	none
	19	20.5(q)	0.97(d, 6.5 Hz)	C-14, C-18, C-20
	20	22.2(q)	0.93(d, 6.5 Hz)	C-14, C-18, C-19
30	21	49.6(q)	3.22(s)	C-4
	1'	166.7(s)		
	2'	115.9(d)	6.57(d, 15.5 Hz)	C-1, C-4'
	3'	136.4(d)	7.55(d, 15.5 Hz)	C-1', C-2', C-4', C-5'
	4'	138.4(s)		
35	5'	122.9(d)	7.10(s)	C-4', C-7'
	7'	139.5(d)	7.48(s)	C-4', C-5'
	9'	33.6(q)	3.72(s)	C-5', C-7'
	1"	93.4(d)	4.91(d, 3.7 Hz)	C-3", C-5"
	2"	71.8(d)	4.99(dd, 9.8, 3.7 Hz)	C-3", C-1"
40	3"	68.1(d)	4.03(dd, 9.8, 3.7 Hz)	C-2"
	4"	69.5(d)	3.99(m)	C-3"
	5"	62.1(t)	3.70(d, 11.9 Hz)	C-1", C-3"
			3.83(d, 11.9 Hz)	C-1"
	1"	171.4(s)		
45	2"	21.0(q)	2.11(s)	C-1"
	a —	acquired at 50 MHz in CDCl <sub>3</sub>		
	b —	acquired at 500 MHz in CDCl <sub>3</sub>		
	c —	acquired at an effective <i>J</i> = 8 Hz		

TABLE 3

Table of NMR spectral data for eleutherobin			
	label	<sup>13</sup> C NMR	<sup>1</sup> H NMR
5	1	34.5	3.89(m)
	2	135.2	5.40(d, 9.3 Hz)
	3	133.0	
	4	116.0	
	5	130.8	6.08(d, 5.5 Hz)
10	6	133.9	6.27(d, 5.5 Hz)
	7	89.5	
	8	80.9	4.66(d, 5.7 Hz)
	9	30.7	1.32(m)
			1.48(m)
15	10	38.5	2.44(m)
	11	133.9	
	12	121.1	5.28(m)
	13	23.9	1.95(m)
			2.27(m)
20	14	42.2	1.23(m)
	15	67.8	3.77(d, 12.0 Hz)
			4.17(d, 12.0 Hz)
	16	23.9	1.37(s)
	17	21.6	1.47(s)
25	18	28.9	1.46(m)
	19	20.2	0.93(d, 4.5 Hz)
	20	22.1	0.92(d, 4.5 Hz)
	21	49.3	3.09(s)
	1'	166.3	
30	2'	113.8	6.35(d, 11.0 Hz)
	3'	138.1	7.53(d, 11.0 Hz)
	4'	137.3	
	5'	125.0	7.57(s)
	7'	140.2	7.69(s)
35	9'	34.2	3.66(s)
	1"	93.2	4.70(d, 3.4 Hz)
	2"	70.9	4.82(dd, 9.7, 3.4 Hz)
	3"	66.2	3.78(dd, 9.7, 3.4 Hz)
	4"	68.5	3.76(m)
40	5"	63.2	3.44(dd, 12.0, 2.3 Hz)
			3.60 (d, 12.0 Hz)
	1'''	170.1	
	2'''	21.0	2.01(s)
45	a	acquired at 50 MHz in DMSO-d <sub>6</sub>	
	b	acquired at DMSO-d <sub>6</sub>	

TABLE 4

Table of proton-proton correlations for eleutherobin (500 MHz, chloroform- $d_1$ , $J = 8$ Hz)				
	label	<sup>1</sup> H NMR	COSY correlations	NOESY correlations
5	1	3.96(m)	H-2, H-10	H-1, H-2, H-8, H-10, H-14, H-19
	2	5.56(d, 9.3 Hz)	H-1	H-1, H-13 $\beta$ , H-14 $\alpha$
	5	6.12(d, 5.8 Hz)	H-6	H-6, H-15 $\beta$ , H-21
	6	6.09(d, 5.8 Hz)	H-5	H-16, H-2 $''$
	8	4.82(d, 7.7 Hz)	H-9 $\alpha$	H-1, H-10, H-16
10	9	1.39(m)	H-8, H-9 $\beta$ , H-10	H-9 $\beta$
		1.61(m)	H-9 $\alpha$	H-9 $\alpha$ , H-10
	10	2.61(m)	H-1, H-9 $\alpha$	H-1, H-8, H-18, H-19
	12	5.28(m)	H-13 $\alpha$ , H-17	H-13 $\alpha$ , H-13 $\beta$ , H-17
	13	1.98(m)	H-12, H-13 $\beta$ , H-17	H-12, H-13 $\beta$ , H-20
		2.32(m)	H-13 $\alpha$ , H-14, H-17	H-2, H-13 $\alpha$ , H-14
	14	1.23(m)	H-1, H-13 $\beta$ , H-17	H-1
	15	3.88(d, 12.4 Hz)	H-15 $\beta$	H-2, H-15 $\beta$ , H-1 $''$
		4.31(d, 12.4 Hz)	H-15 $\alpha$	H-15 $\alpha$
	16	1.45(s)	none	H-6, H-8, H-21
15	17	1.52(s)	H-12, H-13 $\beta$ , H-13 $\beta$	H-1, H-12, H-17, H-19
	18	1.57(m)	H-14, H-19, H-20	H-10, H-14, H-19, H-20
	19	0.97(d, 6.5 Hz)	H-18	H-10
	20	0.93(d, 6.5 Hz)	H-18	H-9 $\beta$ , H-13 $\alpha$ , H-14
	21	3.22(s)	none	H-8, H-16
	2'	6.57(d, 15.5 Hz)	H-3'	H-3'
	3'	7.55(d, 15.5 Hz)	H-2'	H-2'
	5'	7.10(s)	none	H-9'
	7'	7.48(s)	none	none
	9'	3.72(s)	none	none
20	1 $''$	4.91(d, 3.7 Hz)	H-2 $''$	H-2, H-15 $\alpha$ , H-2 $''$
	2 $''$	4.99(dd, 9.8, 3.7 Hz)	H-1 $''$ , H-3 $''$	H-1 $''$ , H-3 $''$
	3 $''$	4.03(dd, 9.8, 3.7 Hz)	H-2 $''$ , H-4 $''$	H-2 $''$
	4 $''$	3.99(m)	H-3 $''$	H-5 $''\alpha$ , H-5 $''\beta$ , H-19
	5 $''$	3.70(d, 11.9 Hz)	H-4 $''$ , H-5 $''\beta$	H-4 $''\alpha$ , H-5 $''\beta$
		3.83(d, 11.9 Hz)	H-4 $''$ , H-5 $''\alpha$	H-4 $''$ , H-5 $''\alpha$
	2 $'''$	2.11(s)	none	none

25

30

Two sets of NMR spectra are presented in the above Tables (in chloroform- $d_1$  and in DMSO- $d_6$ ) because of overlapping signals in the  $^{13}\text{C}$  NMR spectrum. The chemical shifts discussed below in the following are with reference to chloroform- $d_1$ . Due to the presence of two  
5 carbonyl and 11 other olefinic carbon atoms, one of the nitrogen atoms is part of a double bond while the other one is aliphatic, resulting in eight double bonds and thereby a pentacyclic molecule. The distortionless enhanced polarization transfer (DEPT) spectrum shows 7 quaternary, 17 tertiary, 4 secondary, and 7 primary carbon atoms,  
10 counting for 46 hydrogen atoms. The remaining two protons are attached to heteroatoms. The chemical shifts for  $^1\text{H}$  NMR and  $^{13}\text{C}$  NMR are set forth in FIGS. 2 and 3, respectively.

Except for the signal at  $\delta = 5.28$  ppm, all olefinic signals show simple spin systems. An  $\alpha,\beta$ -unsaturated carbonyl moiety is indicated  
15 by the chemical shifts of the two coupling ( $J = 15.5$  Hz) protons showing resonance at  $\delta = 6.57$  ppm and  $\delta = 7.55$  ppm and by the corresponding  $^{13}\text{C}$  NMR chemical shifts at  $\delta = 115.9$  ppm and  $\delta = 136.4$  ppm. The signals at  $\delta = 6.09$  ppm and at  $\delta = 6.12$  ppm couple with each other ( $J = 5.9$  Hz) and result from protons attached to a Z-  
20 configuration double bond embedded in a ring. The doublet at  $\delta = 5.56$  ppm corresponds to a proton attached to a trisubstituted double bond and couples with an aliphatic methine proton. The other olefinic protons at  $\delta = 7.10$  ppm and at  $\delta = 7.48$  ppm show singlet resonances. The variety of signals between  $\delta = 3.70$  ppm and  $\delta = 5.00$  ppm, together  
25 with the fact that 8 oxygen atoms in addition to the carbonyl oxygen atoms are present, indicates that the molecule contains a sugar moiety. This is further confirmed by the  $^{13}\text{C}$  NMR spectrum which shows six resonances between  $\delta = 60$  ppm and  $\delta = 100$  ppm, including acetal carbon at  $\delta = 93.4$  ppm. The singlets at  $\delta = 3.22$  ppm and at  $\delta =$   
30 3.72 ppm result from a methylated tertiary nitrogen and a methoxy group. The  $^{13}\text{C}$  NMR spectrum in DMSO- $d_6$  shows two different signals

at  $\delta = 113.8$  ppm (olefinic CH) and at  $\delta = 116.0$  ppm (C, acetal carbon) whereas in chloroform- $d_1$ , those signals are overlapping at  $\delta = 115.9$  ppm.

The constitution of eleutherobin was established by extensive 2D  
5 NMR spectroscopy, including correlation spectroscopy (COSY), hetero-  
nuclear multiple bond quantum coherence (HMQC) and heteronuclear  
multiple bond correlation (HMBC) methods. The structure is secured by  
more than 60 HMBC correlations, observed in two different solvents  
(chloroform- $d_1$  and DMSO- $d_6$ ). The assignment of the two olefinic  
10 protons showing signals at  $\delta = 6.09$  ppm and at  $\delta = 6.12$  ppm is  
possible because of an HMBC correlation between H-8 and C-6. The  
position of the oxygen bridge between C-4 and C-7 forming the dihydro-  
furan moiety can unambiguously be concluded from the HMBC and  
COSY correlations established part of the structure, from the sum  
15 formula, and from the chemical shifts shown by C-4 ( $\delta = 115.9$  ppm)  
and by C-7 ( $\delta = 89.9$  ppm). The connections between the diterpene  
core and the urocanic acid and pentosopyranose units are established  
via HMBC correlations between H-8 and C-1' resp. H-15a, H-15b and C-  
1". The 2"-position of the acetoxy group is established by the chemical  
20 shift of H-2" ( $\delta = 4.99$  ppm) and C-2" ( $\delta = 71.8$  ppm) as well as by  
the HMBC correlation between H-2" and the carbonyl atom C-1"". The  
atom labels for eleutherobin are set forth in FIG. 1.

Eleutherobin features five carbon-carbon double bonds, one of  
which is part of an N-methyl imidazole ring. The *E*-configuration of the  
25 double bond between C-2' and C-3' can be concluded from the coupling  
constants of the attached protons ( $J = 15.5$  Hz) and from the  
wavelength of the UV absorption ( $\lambda = 290$  nm, methanol) of eleu-  
therobin (1). A *Z*-conformation urocanic acid would have a maximum  
UV absorption at about a  $\lambda$  270 nm). The trisubstituted double bond  
30 between C-2 and C-3 must have a *Z*-configuration for steric reasons.

This structure was also confirmed by NOE correlations as best shown in FIG. 4.

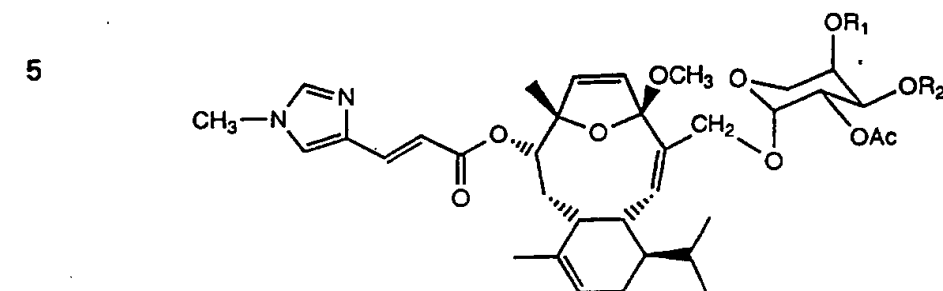
Eleutherobin may be prepared by various routes including: (1) isolation from various *Eleutherobia* species such as *Eleutherobia cf. albiflora* and *E. cf. grayi*; (2) reduction and glycosylation of sarcodictyin A; and (3) total synthesis from conventional starting materials.

An exemplary procedure for isolating eleutherobin from one of the *Eleutherobia* species located in Western Australia is set forth schematically in FIG. 5. The isolation procedure is an eight step protocol which involves using conventional separation procedures to isolate eleutherobin from a freeze dried sample of the animal (WA92033). In step 1, the freeze dried sample is extracted sequentially with methanol, trimethyl pentane and dichloromethane/methanol(1:1). In step 2, the extract (WA92033E3) is subjected to solvent partitioning in methanol/trimethyl pentane. In step 3, the methanol fraction from step 2 (WA92033E3/M) is further solvent partitioned in butanol/water. In step 4, the butanol fraction from step 3 (WA92033E3/M/Bu) is subjected to a further solvent partition in dichloromethane/methanol/water. In step 5, the dichloromethane/methanol fraction from step 4 (WA92033E3/M/Bu/MC-M) is subjected to size exclusion column chromatography using a Sephadex LH-20 column with methanol solvent. In step 6, the third fraction (L3) isolated in step 5 is subjected to another solvent portion using trimethyl pentane/methanol. In step 7, the methanol fraction from step 6 (WA92033E3/M/Bu/MC-M/L3/M) is subjected to silica gel column chromatography using chloroform/methanol (10:1) eluent. In step 8, the third fraction from step 7 is subjected to reverse-phase high pressure column chromatograph using a reversed-phase C-18 column and methanol/water (9:1) as the eluent. The second fraction (R<sub>2</sub>) eluted in step 8 is eleutherobin. As indicated in FIG. 5, the amount of eleutherobin recovered from 150 grams of freeze dried animal will be on the order of 23 mg.

The *Eleutherobia* species which contain eleutherobin are found off the coast of Western Australia near the city of Exmouth. Two exemplary animals (WA92-033 and WA92-034) are similar to *E. albiflora* (Utinomi) and *E. grayi*, but not identical with the original descriptions provided by Utinomi (H. Utinomi, The Alcyonarian Genus *Bellonella* (*Eleutherobia*) from Japan with Descriptions of Two New Species. Publications of the Seto Marine Biological Laboratory, Vol. VI, No. 2, pages 160-161, December, 1957.). The two species each contain eleutherobin. The specimen most closely related to *E. albiflora* is red, while the specimen similar to *E. grayi* is smaller, yellow in form. Both animals were collected in the same area. Both specimens are cylindrical colonies measuring approximately 50-60 mm in length and 10 mm in diameter. The polyps over the capitulum are fully extended beyond the slightly raised calyces which are irregularly distributed at intervals of ca 1 mm. Each polyp is colorless and lacks spicules. The pinnules are somewhat clavate in shape, terminating to a globose thickening; the longest one located in the middle measures ca. 0.3 mm in length. The exemplary animal which most closely resembles *E. grayi* (WA92-034) possesses sclerites as short as 0.08 mm, which is in contrast to the original specimens which possess sclerites measuring 0.18 mm.

Eleutherobin may also be prepared by first isolating sarcodictyin A from *Sarcodictyon roseum* as described in the articles referenced in the *BACKGROUND OF THE INVENTION*. The sarcodictyin is then selectively reduced (me ester) and glycosylated in accordance with well known procedures used to add an arabinopyranose unit to sarcodictyin which results in the production of eleutherobin (Gaylord, Reduction With Complex Metal Hydrides, *Interscience*, NY, 1956, pp. 391-531; and Fieser & Fieser, *Advanced Organic Chemistry*, Rheinhold, NY, 1961, pp. 933-937). Eleutherobin may also be synthesized by starting with other known compounds that contain the same ditrpene skeleton as eleutherobin.

The present invention also covers analogs of eleutherobin having the formula:



where  $R_1$  and  $R_2$  are H or acyl groups having from 1 to 6 carbon atoms. These ester analogs of eleutherobin can be prepared by using conventional synthesis procedures in which acyl groups are substituted for the existing hydrogen atoms present at the  $R_1$  and  $R_2$  positions in eleutherobin. The ester analogs where  $R_1$  is methyl and  $R_2$  is H or where  $R_1$  is H and  $R_2$  is methyl are preferred.

Eleutherobin and the above described analogs are useful as cytotoxic agents. The compounds are used in the same manner as other known cytotoxic agents. They may be used alone or in combination with suitable pharmaceutical carriers and other bioactive materials. They are used both *in vitro* and *in vivo* to kill a wide variety of cell types. Eleutherobin and its analogs have been shown to be cytotoxic with respect to cancer cells. For example, *in vitro* toxicity of eleutherobin was tested in the HCT116 human colon carcinoma cell line and a multidrug resistant subline, HCT116/VM46, which overexpresses P-glycoprotein and is over 100-fold resistant to taxol. Eleutherobin was nearly as cytotoxic as taxol in the HCT116 cell line and was 52-fold cross resistant in the HCT116/VM46 subline. The cytotoxicity of eleutherobin was also tested in a human ovarian carcinoma cell line A2780. Eleutherobin was also found to be cytotoxic with respect to the



15

A2780 cell line. The results of the above cytotoxicity assays are set forth in TABLE 5.

TABLE 5

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<i>In vitro</i> Cytotoxicity of Eleutherobin Against Taxol Sensitive and Resistant Human Colon and Ovarian Cell Lines			
	IC <sub>50</sub> (nM) <sup>1</sup>		
	HCT116	HCT116/VM46	A2780
paclitaxel (taxol)	4.6	5.37 (117) <sup>2</sup>	6.7
WHF P 92033	10.7	554 (52)	13.7
<sup>1</sup> Cytotoxicity was determined after 72 hour exposure by XTT assay. <sup>2</sup> Value in parenthesis is fold resistance relative to corresponding parent cell line.			

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Having thus described exemplary embodiments of the present invention, it should be noted by those skilled in the art that the disclosures herein are exemplary only and that various other alternations, adaptations and modifications may be made within the scope of the present invention. Accordingly, the present invention is not limited to the specific embodiments as illustrated herein.

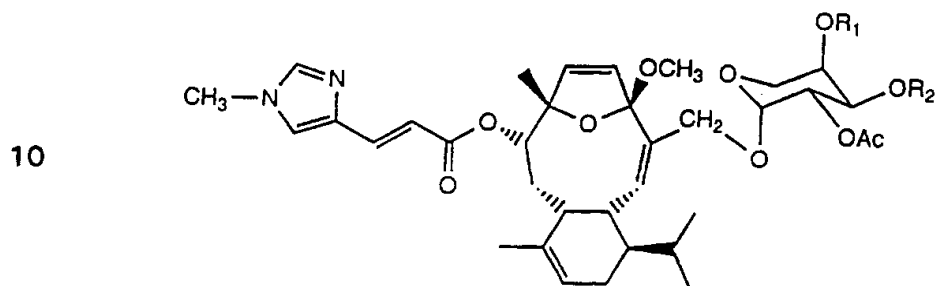
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CLAIMS

What is Claimed is:

1. A composition of matter comprising a compound having the  
5 formula:



- 15 where R<sub>1</sub> and R<sub>2</sub> are hydrogen or an acyl group having from 1 to 6 carbon atoms.

2. A composition of matter according to claim 1 wherein R<sub>1</sub> is  
hydrogen.

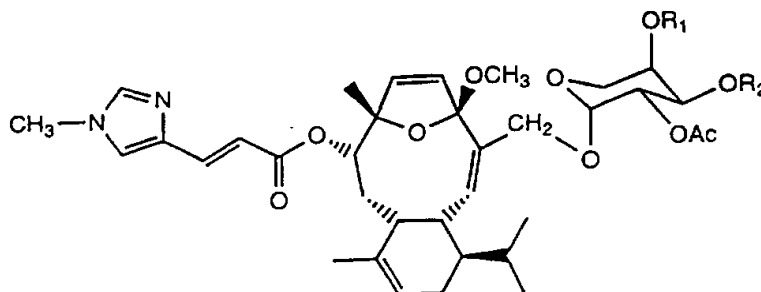
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3. A composition of matter according to claim 1 wherein R<sub>2</sub> is  
hydrogen.

4. A composition of matter according to claim 2 wherein R<sub>2</sub> is  
25 hydrogen.

5. A method for killing one or more cells present in a cell population, said method comprising the step of treating said cell population with a sufficient amount a compound having the formula:

5



where R<sub>1</sub> and R<sub>2</sub> are hydrogen or an acyl group having from 1 to 6 carbon atoms for a sufficient time to kill one or more of said cells in said cell population.

6. A method for killing one or more cells present in a cell population according to claim 5 wherein  $R_1$  is hydrogen.

20            7. A method for killing one or more cells present in a cell  
population according to claim 5 wherein R<sub>2</sub> is hydrogen.

8. A method for killing one or more cells present in a cell population according to claim 6 wherein R<sub>2</sub> is hydrogen.

25

9. A method for killing one or more cells present in a cell population according to claim 5 wherein said cells are cancerous.

10. A method for killing one or more cells present in a cell  
30 population according to claim 9 wherein said cells are human colon  
carcinoma cells.

**18**

**11. A method for killing one or more cells present in a cell population according to claim 9 wherein said cells are human ovarian carcinoma cells.**

**5**

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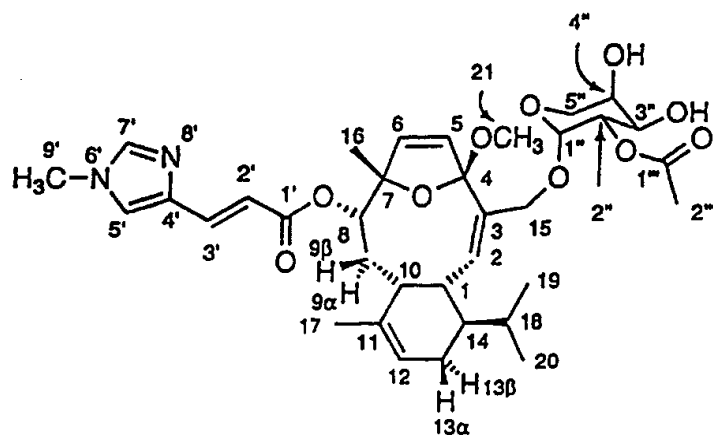


FIG. 1

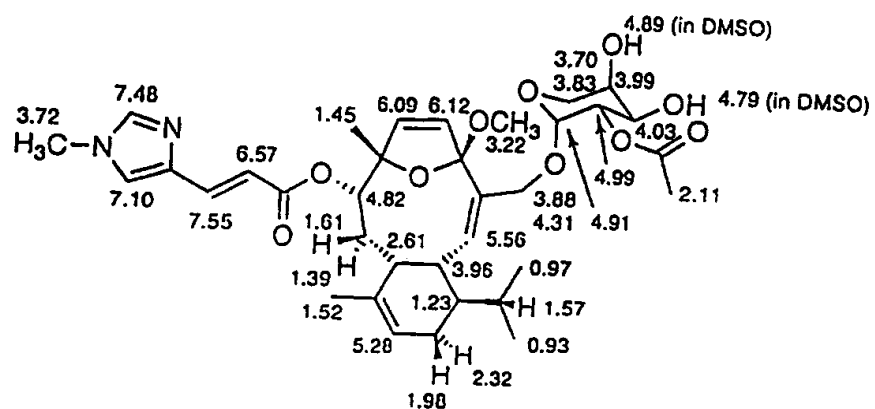


FIG. 2

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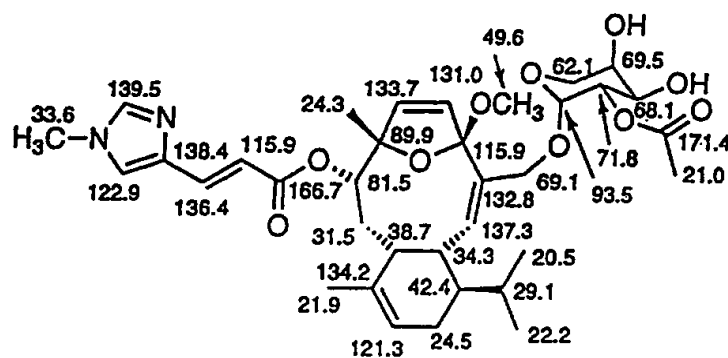


FIG. 3

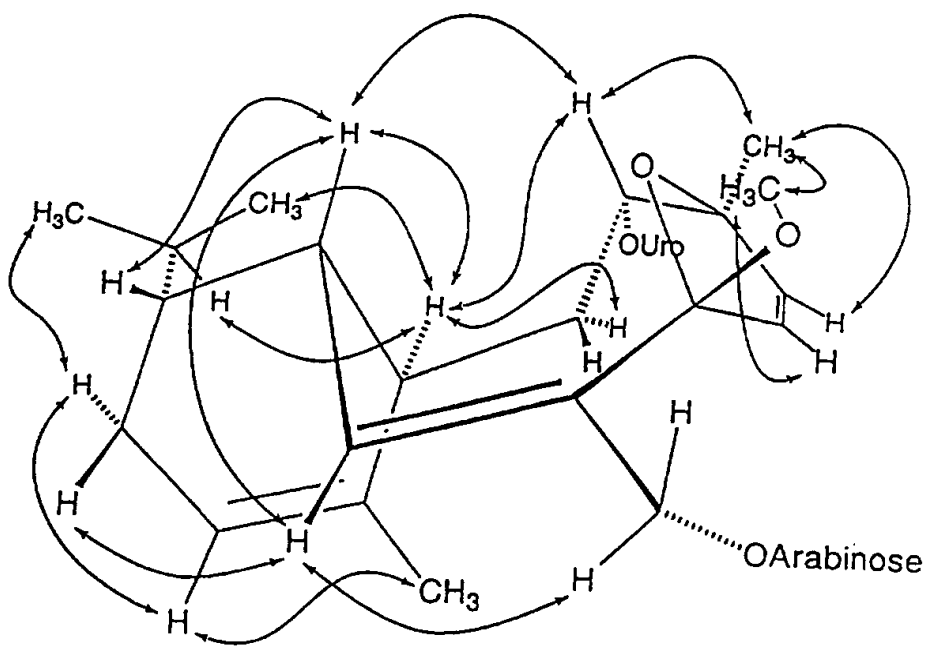


FIG. 4

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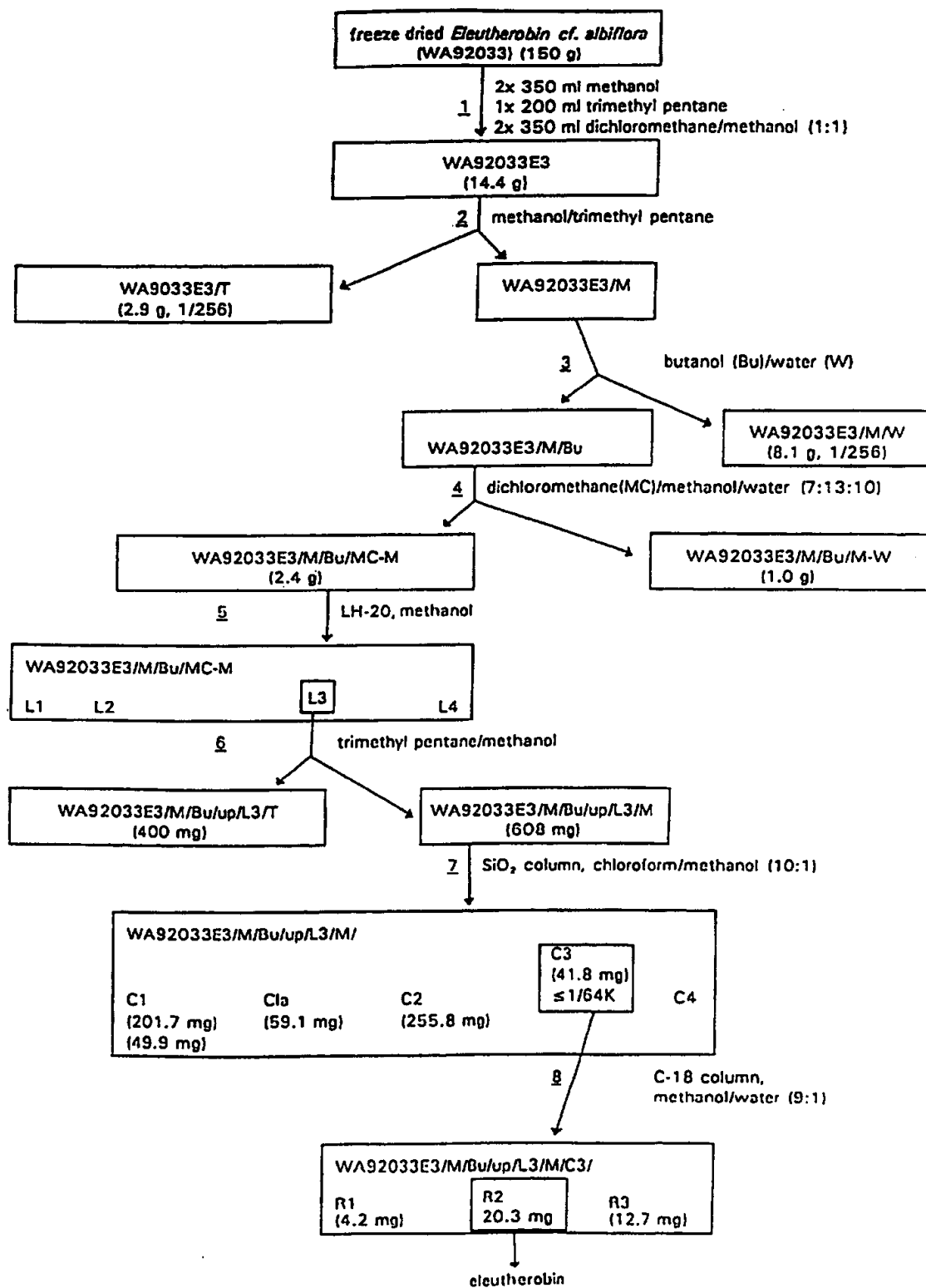


FIG. 5  
SUBSTITUTE SHEET (RULE 26)

# INTERNATIONAL SEARCH REPORT

I. national application No.  
PCT/US95/14155

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : A01N 43/04, 43/08; A61K 31/34, 31/70; C07H 15/00, 17/00

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 514/33, 125, 134, 385, 468; 536/17.3, 18.1, 18.2; 548/311.4, 315.4, 323.5, 324.1, 326.1, 335.1, 341.1, 341.5, 432, 433, 448

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Tetrahedron, Vol. 49, No. 36, issued 1993, Lin et al, "The Valdivones, Anti-inflammatory Diterpene Esters from the South African Soft Coral Alcyonium Valdivae", pages 7977-7984, see entire document.	1-11
A	Tetrahedron Letters, No.24, issued 1968, Kennard et al, "Chemical Studies of Marine Invertebrates. IV. Terpenoids LXII. Eunicellin, A Diterpenoid of the Gorgonian Eunicella Stricta. X-Ray Diffraction Analysis of Eunicellin Dibromide." pages 2879-2884. See entire document.	1-11

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*g*	document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

12 FEBRUARY 1996

Date of mailing of the international search report

25 MAR 1996

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/14155

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	105 Helvetica Chimica Acta, Vol. 71, issued 1988 D'Ambrosio et al, "Isolation from the Mediterranean Stoloniferan Coral Sarcodictyon roseum of Sarcodictyin C, D, E, and F, Novel Diterpenoidic Alcohols Esterified by (E)- or (Z)-N(1)-Methylurocanic Acid, Failure of the Carbon-Skeleton Type as a Classification Criterion", pages 964-976. See the entire document.	1-4

# INTERNATIONAL SEARCH REPORT

I national application No.  
PCT/US95/14155

## A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

514/33, 125, 134, 385, 468; 536/17.3, 18.1, 18.2; 548/311.4, 315.4, 323.5, 324.1, 326.1, 335.1, 341.1, 341.5, 432, 433, 448